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ABSTRACT

This exploratory study was designed to introduce hypertext as a component of classroom instruction in a situation similar to that which might prevail in a public school setting. Linear and non-linear treatments of the same text were employed as an information source for a supplemental learning task prescribed by a teacher as part of classroom instruction. Participants were 80 4th grade students in an elementary school in a suburban school district. The students were grouped by experience with video game technology (high and low) in order to study the influence of that experience on their performance and satisfaction with the two hypertext versions of the learning task. The hypertext used in this study, the geological regions of Minnesota and their products, is related to, but does not duplicate, the content of a required fourth grade social studies unit. In the non-linear version, a hypertext web radiates from numerous graphic choice screens, which allows students at any point to select screens viewed earlier in the lesson, move on to new information, return to previous choice points, or quit the lesson. The linear versions presents all screens in a predetermined sequence, and only has options of continuing the sequence, reversing the sequence one screen at a time, or quitting. Performance was assessed by a student activity sheet, a delayed post-measure, and an attitude survey. No significant main effects or interactions were found for any of the dependent variables. A post hoc exploratory analysis revealed a significant main effect for gender on attitude toward lesson organization. Males found the lesson, regardless of treatment, more clearly organized than did females. (Contains 36 references.) (MAS)

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Linear and Non-Linear Hypertext in Elementary School Classroom Instruction

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Abstract

This exploratory study was designed to introduce hypertext as a component of classroom instruction in a situation similar to that which might prevail in a public school setting. Linear and non-linear treatments of the same text content were employed as an information source for a supplemental learning task prescribed by a teacher as part of classroom instruction. The participants were elementary school children grouped by experience with video game technology in order to study the influence of that experience on their performance and satisfaction with the two hypertext versions. Performance was assessed by a student activity sheet, a delayed post-measure, and an attitude survey. There were no significant main effects or interactions found for any of the dependent variables. A post hoc exploratory analysis revealed a significant main effect for gender on attitude toward lesson organization. Males found the lesson, regardless of treatment, more clearly organized than did females.

Linear and Non-linear Hypertext in Elementary School Classroom Instruction

Hypertext is a form of text made non-linear through integrating a system of nodes and links. Each node of information (often a paragraph) may be linked to any number of other nodes, which are themselves linked to yet other nodes. The nodes of text are interconnected through this potentially complex series of links, which can be organized to convey a variety of conceptual relationships (e.g. hierarchical, spatial, chronological, semantic) alone or in combination. The nature of these linking relationships may or may not be labeled or defined for the user.

The hypertext user moves from node to node through the linked web of textual information by selecting a link from among those available at each node. The resultant path through the text cannot be predicted with certainty by the hypertext author, and may vary greatly from user to user. The effect of this random access within the hypertext document is "to overcome the strictly sequential medium of print and paper" (Marchionini, 1988, p. 8).

The hypertext concept of allowing unlimited quantities of knowledge to be stored, organized, and retrieved by the user in any organizational scheme desired, is intuitively appealing, but has been difficult to define. The fact that the technology which allows the creation of hypertext is emerging and changing even as hypertext is being invented and refined makes defining this medium even more difficult, nevertheless, numerous definitions have been proposed. Aust and colleagues (1993) have done as well as anyone: "Hypertext is an array of emerging technologies for accessing, organizing, and relating electronic-based information." As the technology developed to allow visuals, sound, and video to be stored and arranged in conjunction with text, the term hypermedia was coined. Ramaiah (1992), in a summary of hypertext issues, offers this definition: "When a multimedia program is developed in a hypertext environment, the resulting product is called hypermedia."

This definition, of course, raises the question of what constitutes a hypertext environment. Mark Horney (1991) has specified defining characteristics of a hypertext environment: (a) information stored in freestanding nodes, (b) nodes connected by associative links, (c) active engagement required of users and authors, (d) the system not dependent on any particular informational structure or medium of presentation.

Although not a new concept, hypertext has been readily available for instructional use only since the recent introduction of Hypercard and similar software for personal computers. This availability has generated interest in potential instructional applications of hypertext. Interest has resulted in the appearance of numerous theoretical, conceptual, and speculative essays on hypertext. Reviewers of this literature (Tsai, 1988; Heller, 1990; Ambrose, 1991; Park, 1991) have identified characteristics of hypertext such as non-linear structure, linking ability, and ability to adapt to or support a learner's associative thinking processes.

In addition to identifying characteristics, the reviewers of hypertext literature often list problems associated with learner use of hypertext. Jonassen (1988) provides a typical list of items: (a) navigation through hypertext, (b) selecting an appropriate user access point within a hypertext document, (c) integration by learners into their own knowledge structure what has been learned in the hypertext, (d) cognitive overload caused by the richness of non-linear representation.

Research and Theory

One area discussed by theorists but not directly addressed by research is the issue of hypertext as a new discourse form and the related issue of developing a rhetoric for that form. Norton (1992, p. 42) maintains that "Hypertext/hypermedia as discourse suggests that knowledge can be derived not only from hierarchical, analytical relations of superordinance and subordinance, but also as complex networks which transcend narrow, disciplinary boundaries." According to Norton (p. 40), this leads to ". . . a shift in both the process and outcomes of knowing." Bevilacqua (1989, p. 162) says, "Over time and use, hypertext will probably change our way of thinking. . . ." Slatin (1990, p. 871), in his discussion of a possible rhetoric for hypertext, points out that presently, "The assumption that reading is a sequential and continuous process is the foundation on which everything else rests." He goes on to identify three classes of hypertext readers: browsers, users, and co-authors. "The relationship between these three classes can be fuzzy and therefore difficult to manage" (p. 875).

The published literature on hypertext contains relatively little experimental research. Jonassen's (1988) assertion that, "Hypertext design is theory-rich and research-poor," remains accurate today. In the hypertext research literature, many studies deal with large hypertext database systems, which Rada (1991) has termed "large volume" or "macrotext." These studies address issues such as the use of browsing tools to aid in navigating through large hypertext database systems containing numerous documents (Nielsen, 1990). "Small hypertext", (microtext), consisting of single documents or lessons, can now be authored and used on inexpensive personal computers in classrooms and other instructional settings. At this time, there is relatively little research to guide the design or effective utilization of this instructional hypertext.

Of the studies exploring instructional applications of hypertext, only a few address the implications of its characteristic of non-linearity in an instructional setting. Yet, in the literature, the hypertext problems most frequently cited relate directly to the non-linear nature of the medium. A variety of terminology is used to describe this problem area, including: cognitive overload, getting lost in hyperspace, unmotivated rambling, and disorientation. The theorists suggest that hypertext may be too unstructured and confusing for learners to use efficiently and effectively.

The experimental results with instructional hypertext have been limited and mixed. McGrath (1992), Way (1992), Lin (1991), Lanza and Roselli (1992), and Harris (1990) all tested students' mastery of lesson content after completing alternate versions of the same lesson. In each study, a non-linear hypertext version was compared to one or more linear presentations of the same text.

McGrath (1992) compared four treatment types: hypertext, CAI, paper and a "NoMenu" linear computerized text. College undergraduates were assigned to high and low spatial skills groups and received instruction in calculating surface area and volume. While the study focused primarily on the issues of learner control and student misconceptions, the treatments varied as well in linearity. Subjects in the paper treatment group scored highest on the post-test problems, followed by hypertext, CAI and NoMenu. The hypertext group took the least amount of time to complete the lesson.

Way (1992) compared three lesson treatments: non-linear hypertext, linear CAI, and linear CAI with repetition option. The subjects were college undergraduates. The lesson dealt with basic psychological terms. While there were no significant differences in post-test achievement scores, the hypertext group took significantly longer to complete the lesson. However, a post-hoc examination of learners' paths through the hypertext showed that those in the hypertext treatment group who selected a non-linear path through the lesson, completed it in the same amount of time while still scoring as well as students in the other two treatments.

Lin (1991) compared linear and non-linear computer-based word processing tutorials with college-age subjects. Two of the three treatment groups were given the same hypertext instruction. One of these hypertext groups received ten minutes of training and practice on the features of the hypertext just before the lesson. A third treatment group used a linear tutorial. The hypertext group with training and practice scored significantly higher on both the immediate and the delayed post-tests.

Lanza and Roselli (1991) compared a linear CAI treatment with a hypertext in computer programming instruction at the college level. Post-test results found no significant advantage for either treatment, though more hypertext subjects found their program "stimulating and attractive." The authors noted that while mean group scores did not differ, the range of scores in the hypertext group was greater than in the linear group.

Harris (1990) compared computer-based linear text and hypertext in college computer literacy instruction. Instruction consisted of a lesson on computer communication lasting about forty-five minutes and followed by a post-test. There were no significant differences in post test scores by treatment.

Achievement results by gender, and the amount of time required to complete the instruction also yielded no significant results.

While the results of these studies do not demonstrate superior achievement results for non-linear hypertext as an alternate delivery system for computer-based lessons, they show that in some circumstances hypertext can be equally, or in some cases more, effective than other systems for delivering textual information to learners. However, the studies reveal no clear pattern of superior time efficiency, post test improvement, or lesson enjoyment, for any one lesson type.

Implications of Hypertext Literature

If the goal is to identify effective uses of hypertext in instruction, these results suggest that it may not be not fruitful to approach hypertext only as an alternate delivery system for factual information in computer-based lessons. Revisiting the characteristics of the medium, one might suppose that hypertext's strength could lie in the representation of conceptual relationships among textual information, and that its use in instruction might best involve modeling or representing those relationships for learners (Jonassen, 1988; Carlson, 1990). While some hypertext systems are being developed according to the principles of cognitive flexibility theory to provide models for use with case-based instruction in complex and ill-structured domains (Spiro, Feltovich, Jacobson, and Coulson, 1991), this approach has not been investigated on a smaller scale within a more clearly structured domain.

Another potentially important issue not addressed in any of the studies is suggested by McGrath (1992, p. 529) in her discussion of results: "Apparently 22-year-old students are simply more accustomed to learning from paper than from computer regardless of degree of learner control. Students will need more practice using the computer for learning." It may be significant that the participants in all four studies were college-age or adult learners. It is possible that the factor of learner age (and its attendant prior experience and mind-set) could significantly affect a learner's approach to and success with a non-linear medium presented via computer.

Norton (1992) in her essay on the computer as discourse, points out that the relationship between the sender of a message, the receiver, and the topic is culturally determined. Observing how today's elementary school age child, born into a world of videocassette recorders and remote controls, uses television might be helpful to those interested in analyzing and researching hypertext. This child may readily browse through his or her favorite tapes, skipping passages and reviewing at will. Television for this child appears much less linear than for passive television watchers. The same child may also be observed spending hours navigating the obscure levels of several video games, searching for strategies which allow non-linear movement among the "worlds" and screens of the games.

Norton might say that the child has acquired a new discourse form not generally practiced by adults; a discourse form probably not anticipated by observers at the time remote controls or video games were first introduced. It might be fruitful to speculate that a similar process may occur with the increasing availability of hypertext. Perhaps children born into a world in which hypertext is common will adopt that discourse form as readily as today's children have adopted video. It has, however, been suggested that younger learners would be distracted by the nonessential information presented and cognitive overhead required in the use of hypertext (Heller, 1990).

Although there has been some investigation of the relationship between children's attitudes toward computers and their attitudes toward video games (Fisher and Pulos, 1983), the potential effects of their video experience on success with computer applications such as hypertext have not been explored. It is possible that these video experiences have encouraged younger learners to develop some skills or attitudes which allow them to work more effectively than today's adults with non-linear hypertext in instructional settings.

Study Design Rationale

Influence of Prior Research

Several characteristics of the design of this exploratory study were influenced by the instructional hypertext studies previously cited. These factors include the age of the subjects, the form of the instruments used to measure knowledge acquisition and retention, and the inclusion of an experience factor in the experimental design.

Testing instructional hypertext with younger subjects appeared to be an obvious extension of the previous studies, all of which were done with young adults. A recently published instructional hypertext study (Shin, Schallert and Saveyne, 1994) has taken this same approach. A further consideration in the

decision to work with younger learners was to investigate the potential influence of children's video technology experiences on their use of a non-linear discourse form. Using younger subjects allowed the introduction of video game expertise as an experience factor. In an article published after this study was conducted, Kahn and Landow (1993) have also argued for the importance of considering prior experience as an important factor in learners' success with hypertext.

Post tests employed in previous studies measured retention of factual knowledge, or success in applying the formula modeled in instruction, consisting of various formats of computerized lessons. As Spiro et al. (1991) suggest, presenting items of verbal information or modeling a step-by-step process may not be the most appropriate instructional applications for a non-linear medium like hypertext. Consequently, retention or application of this sort of information may not be the best measure of the effectiveness of the medium. In addition, such measures in previous studies had delivered no clear pattern of results.

For this study, a student activity sheet was chosen, in an attempt to measure, not the retention of facts, but the quantity of information accessed in the process of solving a teacher-assigned problem. It was designed to allow comparison of how effectively students using the linear and non-linear versions of a text accessed and used the required information. The delayed post-test instrument selected was modeled on a graphic organizer (Pehrsson and Robinson, 1985). Its selection and design were influenced by the theoretical discussions of potential relationships between hypertext structures and learners' knowledge structures. It was designed to assess, not only the quantity of factual information retained, but also the effect of a hypertext structure on learners' perceptions of relationships between those facts.

Influence of School Experience

Another major influence on the design of this exploratory study was the author's experience as a media technology specialist at the elementary school level. Observation of elementary school classroom practices, and experiences with computer availability and utilization in elementary schools, influenced decisions about the curriculum content, the instructional role of the hypertext materials, the assessment instruments, and the scheduling of the experimental treatments.

The hypertext treatment in other studies has been a teacher-independent computerized lesson matched with other CAI or paper-based treatments of the same lesson. This type of hypertext application may be unrealistic for public schools, given the limited availability of hardware and the labor-intensive instructional delivery commonly found in the school setting. In an attempt to model common elementary school classroom practice, the hypertext in this study was introduced as one of the several information sources being prescribed as part of teacher-directed instruction.

The content of the hypertext lessons employed in previous studies has consisted primarily of verbal information (psychological terms, computer terminology) and application (using a mathematical formula, introductory word processor operations). The text content used in this study consisted of interconnected facts comprising a body of knowledge. The assigned problem required the student to locate specific factual information from within that body of knowledge and to employ those required facts in a task (worksheet) involving reporting, restructuring, or classifying the information. The design was an attempt to shift, as Spiro et al. (1991) suggest, from an orientation "that emphasizes the retrieval from memory of intact preexisting knowledge to an alternative constructivist stance which stresses the flexible reassembly of preexisting knowledge to adaptively fit the needs of a new situation" (p. 25). This design was also an attempt to employ the hypertext as a supplemental information source supporting a learning task assigned by a teacher as part of classroom instruction. The learners were required to function as "users" and/or "browsers" (Slatin, p. 871) as they worked on teacher-directed tasks which required information contained in the hypertext. The intent of the design was to create a classroom environment in which the hypertext was used as one of several textual tools available to the instructor and the learners as they progressed through a unit or lesson -- a potential instructional role for hypertext which could be a good match to its intrinsic characteristics.

Since in many school settings, access to computer labs is limited, the use of hypertext in computer-based lessons is also likely to be limited. Teachers are more likely to have access to one or two computers within the classroom. The use of hypertext in this study in a supplemental assignment which could be done independently by students throughout the school day, was an attempt to create a design which could study hypertext use in a setting similar to that which might actually exist in many elementary school classrooms.

Materials

Hypertext

The content of the hypertext used in this study, the geological regions of Minnesota and their products, is related to, but does not duplicate, the content of a required fourth grade social studies unit. Prior to the study, the hypertext material was tested with two fourth grade classes in another school. The vocabulary, reading level, and structure of the presentation were judged by fourth grade teachers as being appropriate for that grade level.

In the non-linear version, the hypertext web radiates from numerous graphic choice screens. The content consists of information on each of four geologic regions. The content within each region is organized into four sub-topics: land, products, plants, and the past. Within each sub-topic the content is divided into an information section and an activities section. On entering the non-linear version, the student selects a region from the choice screen. Whenever a region is selected, the four sub-topic choices are then presented for selection. The choice between the information and activities sections is similarly presented on entering each subtopic. The structure provides some guidance for topic selection, in that as each sub-topic on a region is completed, the student is returned to that region's choice screen. However, free access to the entire web is available from every screen through a consistent "quit" button. Pressing this button at any point returns the user to a summary choice screen which graphically displays the four regions and the four sub-topics within each region, with check marks by each which the student has previously selected. A click on any of these icons moves the student directly to that region and topic. This allows students at any point to select screens viewed earlier in the lesson, move on to new information, return to previous choice points, or quit the lesson.

The non-linear hypertext was modified to create a linear version which presents all the screens of the non-linear version, but in a predetermined sequence. In the linear version, the learner has at all times the option of continuing through the pre-determined sequence of screens, reversing the sequence one screen at a time, or quitting. There are no choice screens available, except a warning screen to determine if a student who selects "quit" really wishes to do so.

Both versions were constructed to allow one thirty minute work session per user. When the time expires, the student is forced to quit the lesson. This feature was included to allow comparison of the amount information located and reported on the worksheet by users of linear and non-linear versions within the same amount of work time.

Activity Sheet

The format of the activity sheet completed by students during the thirty minute hypertext session was similar to that of materials used with the required social studies materials. Content of the items was based on the hypertext. Some completion items (e.g. Name the main industry of the Superior Upland area _____.) required locating in the text a single fact and reporting it. Other, more complex items, required locating facts from several areas of the text and combining them in a single answer. For example, a partially labeled Venn diagram (a format familiar to students from previous social studies lessons) required recording some of the farm products of each of two geographic areas, and those which are common to both areas. Several questions made use of graphic maps similar to those located throughout the text to record information found in one or more areas of the text.

The activity sheet was developed by the researcher after reviewing a number of similar sheets used in the fourth grade social studies curriculum. It was then reviewed and revised by several fourth grade teachers who judged the reading level and difficulty of the items as appropriate for fourth grade students. Next it was tested by observing individual fifth grade students complete it using both the linear and non-linear hypertext versions, and by interviewing those students after they had completed it. From these observations and interviews, wording was adjusted to eliminate confusing items, the items were ordered so that information needed for an answer might be found in any part of either hypertext version, and the length of the activity sheet was adjusted to what was estimated to take an efficient student slightly longer than thirty minutes to complete. Finally, a scoring system was developed and tested in conjunction with a pilot run of the study using a smaller (N=51) sample of fourth grade students.

Delayed Post Measure

As mentioned earlier, the post measure was intended to measure retention of factual information, and to assess any affect of the hypertext's structure (linear or non-linear) on the student's awareness of the relationships between those facts. Several possible test formats were considered, including the ordered tree technique (Naveh-Benjamin, et al, 1986), word associations or graphing techniques (Shavelson, 1974), and pattern notes (Jonassen, 1987). None of these seemed appropriate for an exploratory study with elementary school age subjects.

Eventually, a format modeled on a graphic organizer (Pehrsson and Robinson, 1985) was selected as most appropriate for use by this age group in a classroom setting, efficient to administer and score, and offering the possibility of making some inference about the effects of the hypertext structure on students' perceptions of relationships between individual facts. Several designs were then reviewed by the consulting teachers. The one selected was similar in design to the graphic map and choice screens used throughout the hypertext.

A single page displayed the graphic map showing the four regions. Next to each region a large empty rounded rectangle was divided into four sections labeled with the names of the four sub-topics. The directions stated, "On this page, write or draw anything you remember about the regions of Minnesota." Two examples of factual information correctly placed, one a drawing, one written, were included. When the test was administered, the directions were repeated orally three times at intervals, along with encouragement to think back to the hypertext work time and draw or write whatever came to mind. The administration and scoring procedures were developed and tested in conjunction with the cooperating teachers at the time of the pilot run.

Video Game Experience Assessment Instrument

The instrument used to assess video game experience and expertise was developed with the assistance of student volunteers, the cooperating teachers, and several additional pilot classrooms. The first pilot version was constructed by interviewing several highly experienced high school age video game players. It posed numerous factual questions about specific game systems and strategies. However, the wide variety of games and systems available to students made these questions too hard for the panel of elementary school video game student experts who reviewed it. Even these acknowledged sixth grade expert players scored poorly on this initial version. Additional interviews with the younger users led to the development of a second version which combined survey questions about game use (e.g. "If you have any of these game systems at home, circle the ones that you have.) with a few factual questions about the most popular games and systems of the day (e.g. "How many warp zones are there in the game Mario Brothers?"). This version was then tested and discussed individually with several fourth grade students of varying video game expertise.

Finally, a multi-stage classroom testing process was undertaken which involved administering the instrument, interviewing students and teachers, and comparing the scores with teacher ratings and student peer ratings of video game expertise. This process was repeated, with minor revisions to the instrument, in four classrooms in three different schools. In the last of these pilot tests, the instrument achieved a correlation of .7 (N=90) with the peer ratings.

Attitude Survey

The attitude survey was modeled on forms used in previous studies. It contained twelve Likert scale questions designed to measure two issues: lesson enjoyment (e.g. "I would like more lessons like this one."), and lesson organization (e.g. "The computer lesson was confusing."). The sub-scales for these two issues contained six items each. Of these, three were worded positively, and three negatively. Responses were consistently labeled Strongly Agree - Strongly Disagree, and scoring (1-5) was reversed when appropriate to the wording of the question. The six items for each sub-scale were combined and compiled in random order on a single form for the final twelve item test.

The Study

Research Questions and Design

The primary questions addressed by the study were three: Which text structure, linear or non-linear, is used more effectively as a source of information in an assigned problem-solving task? Does the structure of the hypertext, linear or non-linear, affect retention of facts or perception of the relationships between facts? Are frequent users of video game technology more successful than infrequent game users when working with non-linear hypertext? Other questions considered were: With which treatment, linear or non-linear, are participants most satisfied? Do frequent and infrequent video game users vary in their preference for treatment type? Is preference for a particular treatment related to higher scores on the assigned task?

The experiment was of a 2x2 factorial design. The two treatment levels were Linear and Non-linear Hypertext. The two experience factors were High and Low Video Game Experience The three dependent variables were the number of items completed correctly on the activity sheet, number of correctly placed items on the delayed post measure, and the Likert ratings of lesson enjoyment and lesson organization

Participants

The participants were eighty fourth grade students comprising three self contained classrooms in an elementary school in a suburban school district. The study was conducted, with the cooperation of the participating teachers, in the students' regular classrooms during the school day. Parental consent had been obtained, and students were aware of the study. All students were required to complete the materials used in the study as part of their normal social studies requirements.

Procedures

Prior to the study, all participants had completed the assessment of video game experience form. These were scored and a median split was used to assign the participants to two groups of equal size: High Video Game Experience and Low Video Game Experience.

Equal numbers of participants within the High and Low Game Experience groups were then randomly assigned to the linear and non-linear treatments. Participants were not informed of their group or treatment assignments. They were told that they were trying out some new computer software which other schools might someday use. Following identical procedures, both treatments were delivered concurrently using Macintosh computers located in the classrooms. The use of the Macintosh and mouse was demonstrated briefly for the whole class during their social studies period, then each participant was given a sealed packet containing a disk and activity sheet. Participants each completed the treatment individually, under classroom teacher supervision, during the next three school days.

While using the hypertext at the computer, each student completed the activity sheet.

As each student's thirty minute work time elapsed, activity sheets and disks were collected and the student completed the attitude survey which was also collected. Several days after the lesson was completed, the delayed post measure was administered by the researcher during the class social studies period. After all data had been gathered, a debriefing session was held in each classroom and results were shared with the students and teachers.

Results

Worksheet Scores, Post-Lesson Scores, and Attitudes

Each of the three dependent measures was subjected to separate two way ANOVA's with Video Game Experience and Treatment as independent variables. No significant main effects or interactions were found for any of the dependent variables.

Exploratory Analysis

A post hoc analysis of the data for each dependent variable was completed using a three way ANOVA with Gender as the added independent variable. A significant main effect was found for Gender $F(1,72) = 4.0$, $p<.05$ on the Likert scale attitude score for lesson organization. Males (mean = 3.42) rated the lesson organization as clearer and more easy to follow than did females (mean = 2.91).

Discussion

The study explored several potential extensions to the experimental designs previously used in studies comparing linear and non-linear hypertext: (a) younger subjects, (b) grouping by video game experience, (c) assigned instructional activity rather than computerized lesson, (d) worksheet rather than achievement test, (e) stand-alone classroom computer for lesson delivery rather than mass computer lab, (f) recall post-measure rather than delayed post-test. While the study did not find a significant effect for any one of these factors, the experience gained with these extensions may assist in the design of future studies in this emerging area.

That fourth grade students using both the linear and non-linear versions successfully completed the activity sheet supports the assertion that lesson-length hypertexts can be used effectively by learners at this level. This finding is supported by the recently published Shin, Schallert, and Saveyne study (1994). Student attitudes toward both lesson versions remained moderately positive (1-5 Likert scale, mean = 3.475) after completing them. In addition, the experimenter observed that most subjects appeared to approach the lesson with enthusiasm. These results appear to justify further investigation of hypertext applications at the elementary school level.

That the video game experience factor did not yield significant results may be an indication that the two media, video games and hypertext, are too dissimilar for skills or attitudes to transfer between them. It is possible as well to question the validity of the instrument used in this study to measure video game experience. Information gained in the process of development showed it to be difficult to assess a general level of "video game experience" beyond expertise with individual games or game systems. Further investigation of the influence of experience factors on hypertext use has been

suggested by the results of other studies (Lin, 1991; Kahn and Landow, 1993). Since the selection of video game technology as the experience factor for this study was somewhat arbitrary, the effects of experience with other video or microcomputer applications on hypertext use might be investigated in future studies.

The participating teachers indicated that the employment of the hypertext as an assigned activity supplementary to classroom teacher-directed instruction was appropriate to this particular curriculum area and to their general classroom practices. One potentially confounding factor with this approach is the possibility that variation among teachers in the implementation of the curriculum content related to that presented in the hypertext might affect students' performance in the experimental activity. Future studies may want to control for this potential influence, perhaps by using a pre-test to determine prior content knowledge. Another possible approach would be to use hypertext whose content had previously been introduced to all subjects via uniform readings or a video presentation. The hypertext activity would then be used in a role similar to that suggested by some researchers for instructional simulations (Thomas and Hooper, 1991; Thurman, 1993), to encourage transfer and application rather than acquisition of new knowledge.

The activity sheet, when used in the experimental setting, appeared to be more difficult to complete than the development and pilot results had indicated. It is possible that the length and difficulty of the activity (24 items, mean = 10.38) may have caused some subjects to abandon the task prematurely. Attempting to keep the lesson content appropriate to the subjects' age, resulted in a relatively short (30 minute) treatment time. A treatment of this duration may not have been sufficient to elicit measurable differences in treatment effect, an issue raised recently by Reeves (1993) and relevant as well to some of the previously cited instructional hypertext studies. Future studies might employ treatments of longer duration.

Delivering the experimental treatment throughout the school day via individual computers located in the classroom offered both advantages and disadvantages. The configuration and schedule appeared to be accepted by students and teachers as conforming with routine classroom practice. The experimental procedures appeared to run smoothly as part of the classroom routine, providing a seemingly uniform and non-threatening experience for students regardless of treatment, classroom, or group assignment.

On the other hand, subjects experienced the experimental treatments over the course of three school days. Ongoing activities within the classroom and the school during this time may have resulted in unequal experimental conditions for some subjects. One student, for example, may have worked as the only student in the classroom, while another may have worked at the computer while potentially distracting class activities went on nearby. Choosing between the authenticity of the classroom setting and the more controlled, but perhaps more artificial, computer lab setting is difficult. Perhaps using small groups of classroom-based computers, thus allowing the treatment to be delivered during one class period over several days, or during one full school day, might provide a satisfactory compromise.

The relatively low activity sheet scores and lack of detailed information about subjects' prior knowledge, made interpretation of post-measure scores difficult. In the future, this measure could be paired with a more typical post-test, or compared with a broader test of prior knowledge. The approach attempted by this post measure is congruent with that of some hypertext studies published since its design (Jonassen and Grabinger, 1993; Jonassen and Wang, 1993). Such studies might provide guidance for designing more sensitive instruments for measuring levels of structural knowledge acquisition and retention.

Since none of the previous hypertext studies had found any achievement or attitude differences based on gender, the gender difference in attitude toward lesson organization found in this study was unexpected. This finding is not surprising, however, considering that girls have been shown to use computers less outside of school, and are more likely than boys to self-select out of computing activities in school (Gilliland, 1990). The significant difference in attitude found here, coupled with no difference in achievement by gender, might merit further investigation in light of issues raised about innate vs. socialized gender differences related to information technology (Kirk, 1992).

It might be fruitful, as well, to investigate how interactions between experience level and gender might influence students' attitudes toward a hypertext lesson. Canada and Brusca (1991) report that gender-based attitude differences toward technology disappear when males and females have equal amounts of technology experience. While this study did not find significant attitude differences by experience level, membership in the High Video Game Experience Group was two-thirds male (24 of 36 members were male), and the Low Experience Group two-thirds female (25 of 44 members were

female). Future studies might measure experience with various technologies by gender for comparison with attitude scores. Another approach could be to investigate the nature of the attitude differences in greater detail, perhaps employing an interview or other more sensitive measure of attitude.

Conclusions

Although knowledge acquisition or retention benefits have not been demonstrated for the small-scale hypertext employed in this study, it is clear that this type of hypertext can be used by elementary school students. This finding justifies further investigation of effective instructional uses for hypertext at this level. The attempt in this study to create an authentic classroom setting, instructional task, and measure of student success, may provide inspiration or guidance for the design of future studies in this area.

If there are learner characteristics which influence success with hypertext, they remain to be identified. The exploratory analysis done here suggests that influences of gender on attitude and performance in this area might be investigated further.

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